Precision Measurement of μp Capture in Hydrogen

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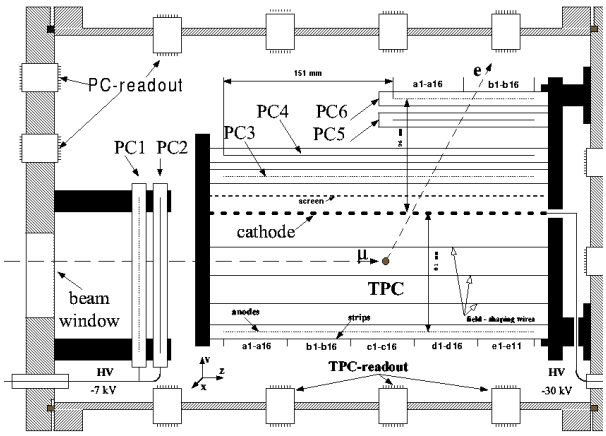
The goal of this experiment is to improve considerably the present knowledge of the rate for the basic electro-weak capture reaction $\mu+p \rightarrow n+\nu$ of a negative muon on a free proton. The proposed measurement to 1% precision will provide stringent tests of theoretical predictions based on Standard Model symmetries and the chiral perturbation theory of QCD. In particular, the capture rate is sensitive to the pseudoscalar form-factor g_p, the least well known among the nucleon charged-current form-factors. The present status of the theory requires measurements of g_p on the few percent level, while the precision of available experiments is worse by more than an order of magnitude.

The capture rate will be determined by measuring the lifetime of μ^- stopped in ultra pure hydrogen at 10 bar pressure with a precision of 10 ppm and comparing this rate to the free μ^+ lifetime. The method[1] is designed to overcome essential limitations of earlier efforts, by providing clean conditions for unambiguous interpretation, muon stop definition and impurity control as well as high statistics. The lifetimes will be measured with a small Time Projection Chamber (TPC) of size 30x15x8 cm^3 hermetically surrounded by proportional chambers. The partially equipped prototype used in first test runs is shown in fig.1.



The system is designed to handle a muon beam of 50 kHz stopping in the TPC volume. In the TPC the negative charges from ionizing particles drift to a plane of anode wires and perpendicular cathode strips where they get amplified by about 5000. The signals are digitized at 5 MHz in continuous mode and collected using custom-built dead-time free TDC's. Real time tracking will reduce the data stream to recordable levels.

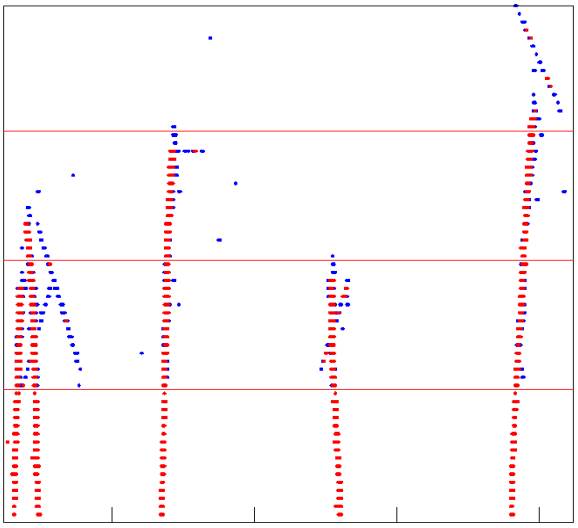


Figure 2 shows a small time section (≈ 80μs) of the continuous TDC display from the test run in December 1999. μ and e tracks can be distinguished by their different ionization density (red and blue). Plastic counters placed outside the pressure vessel and the wire chambers act as independent detectors for muons and electrons allowing precise timing and tracking of single particles.

Footnotes and References

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1. P. Kammel et al., PANIC 99, Uppsala, to be published in Nucl. Phys. A.